seen how futile is the attempt of materialism to find the "cause" of life in any one set of material elements, and how equally futile is the attempt of vitalism to find the significance of the whole in some intangible "force." Both fail to see that any set of processes taken as a whole and in its organic relation to the rest of the universe is its own final and only adequate explanation. Each attributes to natural objects qualities which no single object or set of objects possesses—qualities which afford a complete "explanation" of another object. Both attempt to explain everything in terms of "something else," and this in essence amounts to a denial of the reality of the organic beings which we actually see and deal with.

WM. E. RITTER

LA JOLLA, CAL.

INVESTIGATIONS OF THE CARNEGIE INSTITUTION[1]

WORK in the ten specially organized departments of research in the institution has gone forward during the year with increasing vigor and with increasing productivity. All of these novel establishments may be said to have now passed the preliminary stages of organization, equipment and tentative experience, so that henceforth their efforts and resources may be still more effectively directed and applied. Most of the departments have been strengthened during the year by additions to the staffs of investigators and by accessions to equipment and other facilities, some of which latter have come through the generosity of friends, who have thus shown their appreciation of departmental researches.

But while the existing status of departmental affairs is in general highly satisfactory, it appears essential to again call attention to the fact that with present income and current economic conditions no further expansion of departmental appropriations can be expected. It may be necessary, on the contrary, to curtail research in the departments in order to keep the aggregate expense of the institution within income. It need not follow, however, that this prospective diminution in financial outlay will cause a corresponding diminution of productivity, for work of investigation, like work along other novel lines, is usually most costly in the preliminary stages.

Referring to the current "Year Book" for interesting and instructive details in the reports of the directors of departments, some of the salient features of their activities are summarized in the following paragraphs.

It is a maximum in the pursuit of physical science to proceed from the simpler to the more complex in any attempt to discover the relation among observed facts. In accordance with this maxim, the headquarters of the Department of Botanical Research are located in a desert area where the facts of plant life are exhibited, in general, in their simplest, though often extreme and highly specialized, relations. But even under these favorable conditions plant life presents problems whose solution requires aid from many sciences other than those which are commonly held to make up biology, and especially from chemistry, physics and meteorology. Thus the researches of this department call for much collaboration and for a wide range of observation, experiment and determinate analysis.

During the year the director of the department has continued his investigations on the water-balance of succulent plants, on the conditions of vegetable parasitism, on the variability in plant species induced

[1] From the report of the president.

by chemical treatment of their seeds, and on the influences of climate on plant organisms. In collaboration with Professor Ellsworth Huntington, research associate of the department during a portion of the year, the director has begun a general climatological study of the region about Tucson, giving special attention to the factors and effects of the Santa Cruz and Asuncion river systems.

Dr. Cannon, of the permanent departmental staff, has given attention especially to his elaborate investigation of the root systems and habits of desert plants. For the purpose of extending the range of his studies in this fundamental subject he visited the Sahara Desert and will spend most of the year in that advantageous field for both comparative and direct observations. Some of the more important conclusions already established in respect to this inquiry are set forth in the director's current report.

Dr. Shreve, also of the permanent staff of the department, while occupied with the more general problem of the relation of plants to climate in the United States, has also carried on special investigations of the vital statistics of plants in the vicinity of the Desert Laboratory; of the vegetation in the Santa Catalina Mountains, and of the physiological characteristics of the lace-fern family of plants. In the first of these researches he has been aided by the collaboration of Dr. Livingston, who resigned from the staff of the department a year ago to accept a professorship in Johns Hopkins University.

Observations on the phenomena presented in the drying up of Salton Sea, and especially on the influx of vegetation over the bared strands and islands of this slowly retreating body of water, have been continued during the year. In this work a series of soil analyses of the strands has been secured through the cooperation of Mr. E. E. Free, of the Bureau of Soils of the U. S. Department of Agriculture.

Publications by members of the department issued during the year are shown in the list on pages 32–33 and in the bibliography of the "Year Book." Others in press are Nos. 131, 139, 141. One of these, No. 139, on the guayule, a desert rubber-producing plant of considerable economic importance, is the work of Professor Francis E. Lloyd, formerly a resident associate of the department, but now a member of the faculty of Alabama Polytechnic Institute.

So many converging lines of fruitful research are now being pursued by this department that it is difficult to summarize fitly its current progress. This duty must be accorded, in fact, as in all other cases, to the director of the department concerned, in his annual reports and in his more detailed publications. From the abstract scientific point of view the most interesting feature of this work is found in the introduction of statistical and other quantitative methods, whereby biology is now passing from the first to the next higher stage in the development of a science. From the more popular points of view the work in question is of special interest by reason of its bearing on the economics of plant and animal breeding and by reason of the light it is certain to shed on the laws of human heredity.

So large and so intricate a field of work calls for varied objects and subjects of experimentation and for the resources of many collateral sciences. Thus, studies of heredity have developed the necessity of certain investigations in physiological chemistry, and a small equipment for this purpose has been fitted up in a room of the main laboratory building and put in charge of Dr. R. A. Gortner. Similarly, for

studies of the changes which organisms undergo in dark caves and in deep waters, an artificial cave has been added to the basement of the laboratory, and the work of experimentation by means of this adjunct has been assigned to Dr. A. M. Banta, whose early investigations in this line were printed by the institution some years ago in Publication No. 67.

In order to meet the increasing needs of the department for land for the cultivation of plants and the breeding of animals, the institution purchased in January, 1910, a tract of 21 acres of very desirable land lying about a mile east of the laboratory. It may be noted also that Goose Island, in Long Island Sound, acquired for the department a year ago, has already been put to good use in experiments on plants and animals in a state of isolation.

It is a source of pleasure to record that two friends of the department have shown their appreciation of the director's enterprise by gifts which will greatly aid him in the prosecution of his work: one has supplied a wharf and a shelter house on Goose Island; the other has furnished funds essential to establish, near to but independently of the laboratory, an office for the collection and interpretation, under the direction of Dr. Davenport, of data bearing on human heredity. . . .

The principal steps which have been necessary and in large degree preliminary in the development of the work of the geophysical laboratory are recounted with instructive particularity by the director in his report for the current year. They are the steps required to pass from a merely descriptive knowledge of rock formation to a knowledge based on definite measurements. Briefly stated, these steps are four in number, namely: provision for correct temperature determinations over the entire range involved in the processes of rock formation; provision for like determinations of the chemical reactions of these processes; provision for precise microscopic, optical and crystallographic measurements, and provision for the quantitative applications of high pressures to rock masses and rock constituents.

In supplying the desiderata just indicated for its own special work, the laboratory has already achieved results of prime importance also to many other fields of physical and chemical science. Thus, two contributions of great import to general physics and chemistry have been brought out during the past year. The first of these is a determinate extension of the scale of temperature measures from about 300° C. to about 1,600° C. This is a fitting supplement to the classic work on thermometry begun more than thirty years ago under the auspices of the International Bureau of Weights and Measures. It must take rank, in fact, with the fundamental advances in the technique of thermometry. The other contribution is a determination of the system of compounds which may arise in combinations of the three most important oxides entering into the composition of rocks, namely, silica, lime and alumina. This system is of special economic interest, since it includes, among many other compounds, the hitherto much studied but baffling Portland cement. The complexity of the investigations required to analyze this system is indicated by the facts that it involves the interaction of fourteen minerals and the formation of sixteen ternary eutectics, or substances whose melting-points are lower than those of the primary constituents.

Many other important investigations are outlined in the director's report and the productivity of the laboratory may be inferred from his citation and review of twenty-five publications emanating from

the staff during the year. It is of interest to note in this connection that researches from the laboratory find ready access for prompt publication through current journals both at home and abroad. Many of these papers have already been published in German as well as in English and arrangements have been made during the year to maintain this doubly effective mode of publication.

Six years ago, when the duties of the presidency were assumed by the writer, he deemed it desirable to visit at the earliest opportunity all individuals pursuing researches under the auspices of the institution. It soon developed, however, that a speedy accomplishment of this task would prove quite impracticable, and it became essential to adopt a much more restricted program of activities in this direction. Thus, while nearly all other departmental establishments of the institution have been visited by the president prior to the past year, his first visit to the Tortugas Laboratory was not made until June, 1910. Having already entertained very favorable, but somewhat indefinite, opinions concerning the wisdom of the choice of this locality for a marine laboratory, it is fitting to state that the extraordinary biological resources and the salubrity of the summer climate of the Tortugas group are so evident as to rouse the enthusiasm of any interested observer. As pointed out by the director of the laboratory, the isolation even of these islands furnishes important advantages to the investigator. In brief, the favorable impressions gained during the first visit in respect to the locality and in respect to the scientific spirit and possibilities of the establishment are only tempered by the present incapacity of the institution to give more liberal financial support to this department of work.

Two emergencies seriously affecting the department and calling for prompt action have arisen during the year. One is due partly to the gradual abandonment by the United States navy of the supply depot and wireless station at Tortugas, thus rendering communication between Key West and the laboratory less certain and frequent than hitherto. The curtailment of this source of aid generously extended by the navy to the laboratory during the past six years has forced upon the department the necessity of providing better independent transportation than that afforded by its best boat, the *Physalia*. One object, therefore, of the visit above referred to was to consider with the director the best way to meet this urgent need. Accordingly plans and specifications for a 70-foot twin-screw boat were prepared during the summer; and on authorization by the executive committee, at its meeting of October 18, 1910, a contract for the construction of this proposed vessel was let October 31, 1910, to the Miami Yacht and Machine Co., of Miami, Fla., with the expectation that the contract will be completed July next.

The other emergency arises from the damage to the laboratory caused by the hurricane of October 14–18, 1910. The extent of this damage is not definitely known at the present writing, but steps have been taken to get trustworthy details at the earliest practicable date, so that estimates of the expense required to restore the building may be ready for submission to the board of trustees before their next meeting in December.

It is gratifying to note that the opportunities afforded for intensive research by the laboratory are so highly appreciated that applications for its privileges are already more numerous than can be granted. Each year since its establishment additions have been made to its equipment and the

director hopes that with some minor additions quarters may be found for fifteen or more investigators every summer. During the past season twelve associates, one collector and one artist illustrator, in addition to the director, carried on work at the laboratory. Of the investigators, nine returned to continue work begun in previous years, while two of the other three expect to return in 1911. Many researches are in progress, therefore, as may be seen by reference to the full reports of the director and his associates in the current "Year Book."

Of the publications of the department during the year, special attention should be called to the comprehensive monograph in three quarto volumes by Dr. Mayer, on "The Medusæ of the World," issued as Publication No. 109 of the institution. Two other volumes, Publications Nos. 132 and 133, containing short papers from the director and associates of the laboratory, are now passing through the press.

Capital progress has been made during the year in the large and exacting undertaking which this department has so successfully started. Work at the observatory in Argentina has gone forward at an unprecedented rate and with such a degree of thoroughness and completeness as to give assurances that this part of the enterprise will be completed within the next year. Great credit is properly assigned by the director to the zeal and the industry shown by the resident staff of the observatory in thus completing, within so short a time and without lowering the highest standards of precision, an unparalleled amount of observational work. The general success of this enterprise affords a forcible illustration of the superior effectiveness of a department of research which may proceed with its work intensively in accordance with carefully prearranged plans and organization of effort.

While the supplementary observations of the positions of the stars are going forward in the southern hemisphere, arrangements for the final computations of these positions are proceeding at the Dudley Observatory; for the formidable task of observation must be followed by a still more formidable task of computation. Preliminary to the grand catalogue of stellar positions projected by the department, there has been issued by the institution during the past year, as Publication No. 115, a catalogue of 6,188 stars for the epoch 1900. This has already assumed first rank among catalogues of precision and the demand for it indicates that a second edition may be called for before the larger catalogue is completed. In response to a demand from other astronomers and in view of the needs of his own work, the director has published also, through the Dudley Observatory, a "List of 1059 standard stars for 1910."

Although this laboratory has been occupied less than two years and is not yet fully equipped, it has already produced contributions of fundamental importance to our knowledge of the chemistry, physics, physiology and pathology of nutrition. Its experience, like that of all the laboratories of the institution, affords an impressive demonstration of the productivity attainable by concentrated effort along determinate lines of research. Construction and installation of additional equipment, the prosecution of investigations, and the publication of results have gone forward simultaneously during the year.

One new calorimeter has been completed, another partly constructed, and various auxiliary apparatus for use with these and the earlier equipments have been supplied. Similarly, respiration apparatus for men,

respiration apparatus for dogs, and many improvements in the calorimeter section of the laboratory have been made. Several pieces of apparatus have been acquired also by purchase abroad, and the efficiency of the machine shop has been improved by the addition of a precision lathe.

The investigations under way at the laboratory and outlined in the director's report are too numerous and too technical to permit further abstract or paraphrase. It may suffice here, therefore, to cite one of the most important of these investigations in which decided progress has already been made, but which may yet require many years to complete, namely, the nature and meaning of metabolism in diabetes. In the researches on this recondite problem the director has thus far had the good fortune to enlist the active cooperation of Dr. Elliott P. Joslin, through whose aid especially it has been possible to use the laboratory's apparatus in detailed observations and measurements of a number of diabetic patients during the past two years.

The preliminary results of the research just referred to were regarded as so important as to justify prompt public announcement, and they have accordingly been printed during the year in Publication No. 136. Interest in the laboratory and its work is now so widespread that another volume, describing in detail the respiration calorimeters and their applications, by the director and Mr. Thorne M. Carpenter, has been issued as Publication No. 123. Many shorter publications from members of the research staff have appeared during the year in current journals and in the proceedings of learned societies.

The rapid growth in equipment and facilities and the equally rapid progress in the production of capital results from the researches at this observatory are at once sources of surprise and gratification to the astronomical world. Work during the past year has gone on with little diminution of vigor, although illness of the director has forced him to relinquish his activities for a considerable portion of the time. He has recently gone abroad for a season and the departmental report for the past year has been prepared by Mr. Walter S. Adams, now acting director of the observatory.

The work of this establishment is now so extensive and so varied that it is somewhat difficult to summarize even in its salient aspects. In addition to the observatory proper, with its four principal telescopes and much auxiliary equipment on Mount Wilson, there are the physical laboratory and the instrument shops at Pasadena, along with special divisions devoted to the work of computations and construction respectively. To become conversant, therefore, with the complexity of activities of this department, one must read the somewhat lengthy but relatively condensed annual reports of the director.

By way of equipment several large pieces of apparatus for the new tower telescope, for the 60-inch telescope, and for the 100-inch grinding machine have been made at the shops. The towers for the new 150-foot tower telescope, begun a year ago, are now finished along with the well, 75 feet deep in the rock below, which forms a part of the telescope tube of this novel instrument, now essentially complete except for its spectroscopic attachments still under construction at the shops. Some preliminary trials made recently with this instrument indicate that it will fulfil the sanguine expectations entertained in respect to its capacity.

At the time of the annual meeting of the board of trustees a year ago "The Monastery," a wooden building on Mount Wilson supplying quarters for the resident members of the observatory staff, was com-

pletely destroyed, along with a considerable number of books and other valuable property, by fire. This building has been replaced during the year in somewhat enlarged form by a reinforced concrete structure.

Progress has been made during the year in the details of designs for the proposed 100-inch or "Hooker" telescope, for which Mr. J. D. Hooker, of Los Angeles, made a substantial gift to the observatory some years ago. This work has been in charge of Professor Ritchey, whose construction of the 60-inch reflector has proved so signally successful. After repeated trials and failures to make a satisfactory disk the contracting firm at St. Gobain, France, have quite recently renewed the hope that a disk they now have annealing may meet the exacting requirements set by the astronomers.

Allusion has already been made in an earlier part of this report to the meeting of the International Union for Cooperation in Solar Research held at the observatory during the week of August 29 to September 4 of the current year. An outline of the proceedings of this meeting, which was of peculiar interest to the observatory staff, is given by the acting director at the end of his report. In spite of the difficulties of access to the observatory site, this meeting was regarded as the most important held by the union. Opportunities were afforded the visiting astronomers and physicists to inspect the entire establishment and to test especially the efficiency of the telescopic apparatus. Their appreciation of these opportunities and of the optical perfection of the telescopes, particularly of the 60-inch equatorial reflector, is a source of keen encouragement to the observatory staff.

Attention is invited to the interesting account given in the departmental report of the numerous investigations now under way at the observatory and in the physical laboratory at Pasadena. They are so effectively summarized in this report that any restatement appears superfluous.

No department of research in the institution is conducting work which is at once so obviously practical and so obviously theoretical as the work of the department of terrestrial magnetism. Every one acquainted with the daily use of the compass in exploration, in surveying, and in navigation recognizes the practical utility of a magnetic survey of the earth. But those who recognize that any utilitarian results may come from a deeper knowledge of the earth's magnetism and its cosmic connections are at present very limited in number. Nevertheless, the history of science warrants a confident expectation that the latter results will ultimately prove to be of much greater value than the former.

The more striking events of the year in this department refer naturally to the nonmagnetic ship *Carnegie,* which was off on her first cruise at the close of the previous fiscal year. She was then at Falmouth, England, where her determinations of the magnetic elements were compared with independent determinations made at the permanent magnetic observatory of that port. She proceeded thence, November 9, 1909, to Funchal, Madeira; thence to Hamilton, Bermuda; and thence, under tempestuous conditions which proved her seaworthiness, to Brooklyn, N. Y., where she arrived February 17, 1910. Here she had her copper sheathing applied by the constructors, as required by their contract, and was overhauled and refitted for a three years' circumnavigation cruise. It is a pleasant duty to report that in all essential respects this vessel has proved more effective than was anticipated. It has been demonstrated that even in rough weather

the three magnetic elements (declination, dip and intensity) may be determined with a precision little short of that attainable in a fixed observatory. Thus she was able to discover on her first cruise errors of unexpected magnitude in the best sailing charts of the north Atlantic, and she is certain to attain at least an equal degree of precision in all future ocean work. By crossings of her own tracks and by connections at all available ports having magnetic observatories it will be practicable to exclude the possibilities of any important errors in this work.

Similarly satisfactory progress has been made also in the land work of the department during the year. The expedition in Africa, from the Cape to Cairo, undertaken by Dr. Beattie and Professor Morrison as temporary associates, was completed early in the year, a total of 348 stations having been occupied. Mr. Pearson, field observer of the department, continued work in Turkey in the early part of the year until relieved by Mr. Sligh, who extended the work to Palestine, Syria, Arabia, Mesopotamia and the islands of Rhodes and Cyprus. Up to the end of July of this year these two observers had occupied a total of 47 stations. Another observer, Mr. Stewart, left Washington early in June to begin extensive work in South America, proceeding in the launch *El Imán,* provided especially for work along the Amazon and its tributaries. Additional observations are reported also from Canada and from various European countries in which initial determinations or instrumental comparisons have been made.

The office work of the department has gone forward with corresponding productivity, the large volume of computations required being kept closely up-to-date. The preparation for collective publication of data obtained by the department on land and on sea is now well advanced, although many of these data have been already furnished for use by hydrographic offices and other national and international bureaus. Much critical attention must be devoted by the office staff to the inspection and perfection of instruments and auxiliary appliances. By the aid of a skilled mechanician and a shop now attached to the department it has been practicable to attain a degree of instrumental perfection and a degree of economy in cost not hitherto equalled in this kind of work.

About fifty research associates have carried on investigations under the auspices of the institution during the past year, either by aid of grants made directly to the individuals concerned, or by aid of grants made to organizations like the American Schools at Athens and Rome, or by cooperation with our departments of research. In general, each of these associates has been in collaboration with one or more colleagues or assistants, so that the total of those contributing to this work has been upwards of one hundred investigators. The range of their investigations embraces sixteen distinct fields of research, namely: archeology, astronomy, botany, chemistry, geology, geophysics, literature, mathematics, metallurgy, meteorology, paleontology, philology, physiology, political science, terrestrial magnetism and zoology. Reference must be made, therefore, to the reports of individual investigators and to the general bibliography, to be found in the current "Year Book," for a fuller account of the fruitful activities in this branch of the institution's work. It should be observed, however, that existing and prospective economic conditions, elsewhere referred to in this report, will probably require curtailment in this branch of work in the near future.